



AQMD Demonstration PHEV Prius Conversion Update



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EnergyCS / AQMD

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EnergyCS PHEV Prius Prototype Demonstrator Fleet Summary

- Progress report outline
 - Integration process development
 - Integration issues, platform and component specific solutions
 - Vehicles in service **today** as a result of AQMD project
 - AQMD#1
 - City of Santa Monica
 - Calcars
 - Other early adopter utilities and organizations (SMUD, SCE, PG&E, Manitoba Hydro, Clean-Tech)



EnergyCS Prototype



Project Partners

- Vehicle and test data collection fleet
 - AQMD
 - EnergyCS (2x)
 - City of Santa Monica
 - Calcars
 - Clean-Tech
- Partners providing in kind services
 - Clean-Tech
 - Calcars
 - Valence Technology
- Partners performing testing and evaluation using project vehicles
 - CARB
 - SCE
- Early Adopters
 - AQMD (2+ cars)
 - Manitoba Hydro (Canada)
 - SMUD (HEV America)
 - Amberjac Projects (UK)

Project: Convert 2004 – 2006 Toyota Prius to Plug in Hybrid Electric Vehicle (PHEV)

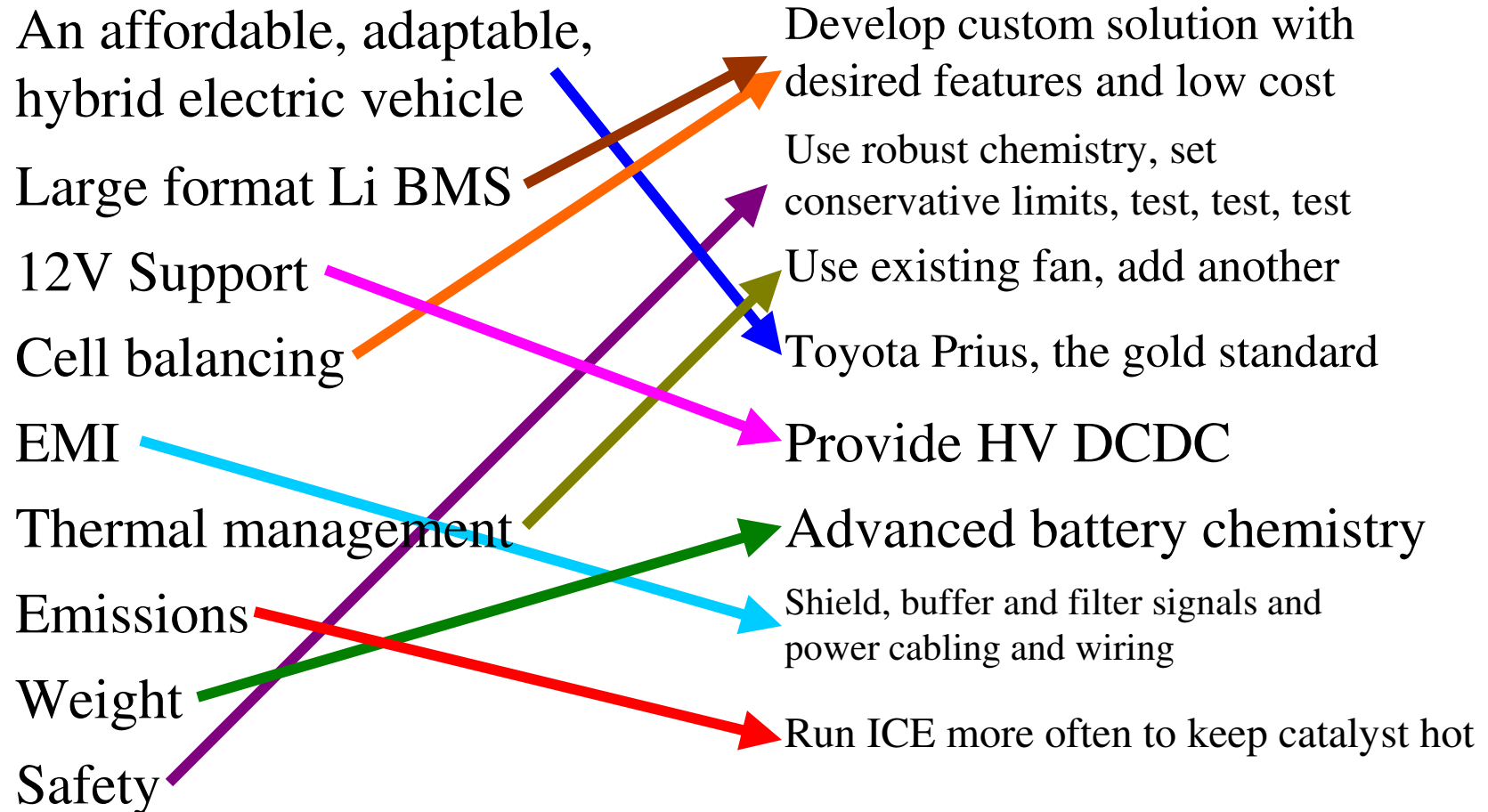
Goals

- ✓ Integrate larger battery pack
- ✓ Increase ZEV mode
- ✓ Improve fuel economy (>100 mpg)
- ✓ Optimize control systems
- ❑ Optimize battery performance and lifetime
- ❑ Develop aftermarket conversion product
- ✓ Provide real world data and examples of plug-ins on the road

Plug in Pack Battery Specifications

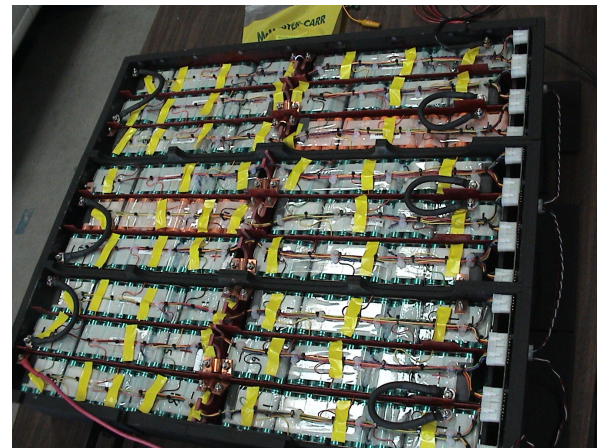
Parameter	Value	Units
Cell nominal capacity (33p x ~1.3Ahr)	42	Ahr
Battery system mass	<120	kg
Net weight increase	~85	kg
Specific Energy	95	Whr/kg
No. of series cells	72	cell
Pack capacity (nominal)	8.5	kWhr
V _{cell,max} OCV	3.45	V
V _{cell,max} (absolute)	3.65	V
V _{cell,min} OCV	3.00	V
V _{cell,min} (absolute)	2.50	V
Temperature Limits:		
Ideal Operating Range	T _{max} < 40, T _{min} > 20	degC
Warning	T _{min} < 10, T _{max} > 50	degC
Shut down	T _{min} < 0, T _{max} > 55	degC

Technology – Issues and Solutions



Integration-Process Development

- Documented processes with a checklist
- Assembly-procedure checklist ensures conformity between vehicles
- Standardized bill of materials for all vehicles



PHEV Integration Issues

- Battery availability
 - Two to four month lead time for batteries
 - Vendor material supply line problems -- manufacturing delays
 - Shipping -- very costly
- Electronics
 - Must meet all vehicle requirements as well as new battery requirements seamlessly
 - Custom design required for application



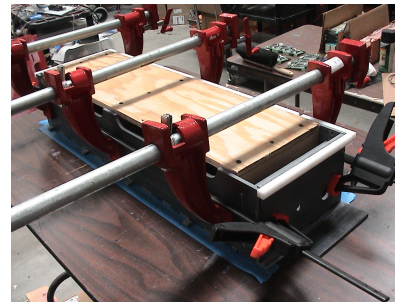
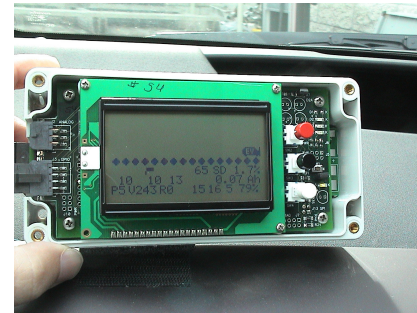
PHEV Integration Issues

- Battery pack structure
 - Little tooling makes assembly time-consuming and skilled-labor intensive
 - Design is driven by thermal and mechanical requirements
 - Components do not arrive in a format they can be packaged and cooled in: much rework is required
 - Requires adding sensing harnesses
 - Custom parts for everything



PHEV Integration Issues

- Testing and validation
- Battery performance
- Vehicle availability
- Materials availability
- Battery management
- Vehicle software integration
- Battery thermal management



Battery System Issues

- Specialized Thermal Management
 - Batteries need extra cooling due to pack-environment as well as PHEV duty-cycle
- Monitoring and balancing of large format Lithium Ion battery
 - EnergyCS developed custom electronics to accomplish this
 - Algorithms in testing and further improvements

Cost / Safety Issues

- Battery cost remains extremely high
- Batteries do not arrive in a format they can be packaged and cooled in: rework is required to integrate batteries into pack configuration
- Conservative LiFePO (lithium iron phosphate) chemistry selection makes pack larger, heavier and more expensive than other less conservative alternatives
- Weight distribution change and pack position may affect vehicle handling or crashworthiness



Commercialization plans

- EDrive Systems, LLC.
 - To be licensee of PHEV technology developed by EnergyCS
 - Focus is manufacturing, marketing and distribution of aftermarket PHEV kits to trained and certified installers, EnergyCS keeps engineering focus, OEM licensing rights
 - Joint venture between principals of EnergyCS, Clean-Tech, LLC and other investors
- Challenges
 - Requires advanced batteries with high energy and power density
 - Requires low cost for profitability: initial desired price point for commercial product cannot be met with present technology.
 - Bridging gap between “early adopter” demonstration of technology and profitable product